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INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT 1945

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Staff.

Mr. P. H. Carpenter retired from the post of Director of the Scientific Department and handed over charge to Mr. C. J. Harrison as Chief Scientific Officer, on the 16th November. Mr. Carpenter joined the Indian Tea Association Scientific Department in 1908 when its Headquarters were at Heeleaka T. E., ten miles from the present Station. During the 1914-1918 War, Mr. Carpenter served in Iraq from 1915 to 1918. In 1919, on the retirement of Dr. Hope, Mr. Carpenter became Chief Scientific Officer and under his direction the Department developed from a comparatively small affair to a well equipped and well staffed research station in the course of 20 years.

In 1929 Mr. Carpenter was nominated to represent the Tea Industry in North and South India on the Advisory Board of the Imperial Council of Agricultural Research and continued to serve on this Board until his retirement from tea.

The war which has recently concluded seriously impaired the work of the Scientific Department. Five of its senior staff were called up for military service, four were employed for most of the war on national service, and for most of the period Mr. Carpenter had to maintain the Department single handed. I can well realise the strain imposed on him during those anxious years when in addition to the problems normal to the maintenance of a Research Station, he had to deal with the problems arising from food shortage, high labour costs, and military occupation of many of the Tocklai buildings.

His contribution to the science of tea culture has been great, and while I and my staff, European and Indian, wish him a long and happy retirement, we are aware of the loss of a great friend and counsellor.

Mr. S. F. Benton (Bacteriologist) has intimated his intention of resigning at the expiry of his present contract in November 1946.

Messrs. Harrison and Macgregor returned from home leave early in November, while Mr. Tunstall proceeded on home leave in October. Mr. Benton continued throughout the year to work on tea manufacture in Darjeeling and Messrs. Wight, Roberts, Winter and Woodford continued in military employ. Their releases are expected early in 1946, when they will take home leave before recommencing their duties with the Scientific Department.

The situation in relation to the Senior staff in 1940, and at the end of 1945 is shown below.

Name	Post held in 1940	End of 1945	Remarks
P. H. Carpenter	Director	Retired Nov. 1945	
H. R. Cooper	Deputy Director	Retired May 1940	
C. J. Harrison	1st Chemist	Chief Scientific Officer	On leave in 1945 (March-October)
A. C. Tunstall	Mycologist	Mycologist	On leave 1945-46 (November-February)
W. Wight	Botanist	Botanist	Still on Military Service
S. F. Benton	Bacteriologist	Bacteriologist	In Darjeeling 1944 to 1946 Resigning Nov. 1946
E. A. H. Roberts	2nd Chemist	Tea Technologist	Still on Military Service
L. C. Comrie	Entomologist	Died 1942	
W. Woodford	Darjeelieg Advisory Officer	Agricultural Chemist	Still on Military Service
E. J. Winter	Surma Valley Advisory Officer	Surma Valley Adv. Officer	,, ,, ,, ,,
F. S. Mitchell	Dooars Advisory Officer	Resigned 1942	
N. M. Macgregor	Senior Advisory Officer	Senior Advisory Officer	On leave 1945 (April-October)

The strength of the staff will thus be 5 less than the pre-war figure, at the end of 1946, when all members will have returned from Military service and home leave.

Buildings: A great deal of reconstruction and repair work is required to make good the damage caused by the 1943 earthquake, and lack of annual repairs during the past four years occasioned by the scarcity and high cost of building materials. Reconstruction of the administrative office and old Chemical Branch was commenced at the end of December.

The miiitary occupation of Tockial buildings ceased early in November, and compensation claims for damage and loss sustained through this occupation have been submitted to the authorities concerned.

With the majority of the senior staff still employed on military work, or on leave, little beyond routine work has been possible, except in tea breeding, a separate report on which is added as an appendix to this report. This is regarded together with research on tea quality, as the most important branch of the Scientific Department's work. Both lines of work however, necessarily demand long term programmes extending over several years, before results of a practical nature emerge. There is therefore some danger of the Industry losing sight of their practical importance, and for this reason, the Agricultural Branch undertook experiments, in conjunction with certain Tea Estates, to demonstrate the improvements which can be effected in quality of tea, its yield and uniformity. It is also necessary to investigate the incidence of disease on areas of tea planted out from vegetatively propagated material, and the influence of environmental conditions on methods used for vegetative propagation. Furthermore it is desirable to have men trained in miniature manufacture and propagation methods in localities throughout the tea districts, and to establish reservoirs of clonal material for future use in selection work. The dispersion of this work throughout the tea districts enables planters and others concerned with the tea industry to see for themselves a few of the problems involved in selection, as well as the advantages which will undoubtedly result.

Tea Breeding.

In 1941 four bushes of outstanding character were selected after tests of yielding capacity and characteristics of the tea made from 180 bushes of Betjan jat. In 1945, a further 1100 bushes were tested and of these 59 were selected. This will be reduced as a result of further tests to about 12.

The original 4 bushes have been vegetatively propagated and from the nurseries so obtained a small area of clonal bushes is now in plucking at Borbhetta. The characterstics of these four bushes are given below :—

Bush No.	Crop mds. per acre.	Valuation.	Quality.	Strength	Briskness.	Colour of liquor	Colour on Infusion	Dry Tea	Tip
2	20	1/3.0	fairly good	fairly good	good	good	bright even	Black	fair
4	36	1/8.2	fairly good	fairly good	good	fairly good	bright greenish	Black	very good
40	25	1/12.2	good	fairly good	good	fairly good	bright greenish	Brownish	very good

160 rose scented tea, otherwise no outstanding character, poor yielder.

Chemistry of Tea.

The study of the nitrogenous substances in the tea leaf referred to in the Annual Report for 1944, was continued in 1945, and a technical paper has been prepared for publication.

In addition routine work of Analysis of soils, manures, samples of tea etc. has been carried out.

Plant Pathology.

Investigations on Black rot (Corticium invisum) were continued and have at last disclosed the cold weather resting stage of this fungus disease. This takes the form of Sclerotia,—groups of fungus cells, which are located inside the tissues of the outer bark of the stems, during the cold weather season. Experiments are now being carried out to find a method of destroying the disease during the cold weather resting stage.

Tests have been made with Gammexane LG037 on white ant nests at the base of tea bushes. It is found that a nest about two feet in diameter and a foot deep, treated on three successive days with 2½ oz. injections of 1½% Gammexane LG037 in kerosene, resulted in complete destruction of the white ants. Failure to kill, was the result of decreasing the strength, quantity or number of applications of the insecticide.

Agricultural

Climate. The rainfall for the year totalled 78·98 ins; There was good early rain, but too much in May and June for a good second flush. July produced low rainfall but August, September and October were normal.

The total area under tea in 1945 was 86·4 acres and the crop 776 mds. tea. This gives a poor average yield of only 9 mds. per acre, but it must be remembered that many plots are unmanured, most are unshaded, and some were not plucked throughout the year.

Cessation of certain experiments. Labour shortage and cost again prevented many experiments from being carried out with pre-war efficiency. It was decided to close down entirely certain trials which were considered to have given all the information which could usefully be obtained from them. Besides which, land is required for the planting of clonal material, which will be put under new trials when it becomes mature.

The results of these experimental areas which are finally closed down are being examined, and will be published during the course of 1946. This also applies to the results of the experimental block of tea at Tulsipara in the Dooars, which was closed down at the end of 1945.

I would like here to extend my grateful thanks to Messrs. Duncan Bros. & Co., Ltd. and their Managers and Assistants who have been concerned in these experiments, for the great help they have given in making these experiments the success they have been, and also for their kindness and hospitality shown to me and my staff on the occasions of our visits to the experimental plots. Mr. P. K. Chakravarti, who has been in charge of the plots since 1934 has worked with great ability in maintaining a high standard of work from the labour, and in keeping accurate records.

Shade Experiments. In our experiments on manuring, pruning, and other cultural factors, it has generally been necessary to use areas of tea entirely devoid of shade.

One of the chief reasons for this is that shade trees normally grow unevenly, and one of the first essentials in experimental plots, is evenness.

It has however been recognised for a long time that the shade tree is essential to the maintenance of first class tea in a great many districts. Although heavy manuring will maintain high crops with no shade, there are times, such as slumps and wars, when manure supplies either become regarded as expensive luxuries, or are obtainable only in small quantities and at high cost. There are times when the shade tree becomes an insurance against inadequate manuring, and it is on the whole wisest to maintain shade even at the expense of some loss of quality in the teas.

Bearing this in mind the Department laid out trials to determine the effect of shade on yield and quality. The first experiment was started on newly planted tea in 1936. In this experiment the tea consists of a variety—well known jats, twelve in number of both dark and light leaf. Some are manured and some not manured. Half the plots are not shaded, and half have Sau (Siris) planted 40ft. apart.

In 1945, its ninth year from planting, the yields were as follows :—

Manuring	Maunds made tea per acre		
	No shade	Shade	Mean increase due to shade
No manure	7·2	14·1	6·9
60 lbs. nitrogen per acre (300 lbs. Sulphate of ammonia)	12·2	16·8	4·6
Mean increase due to manuring with 60 lbs, nitrogen	5·0	2·7	

Previously (when the tea and shade were 5 or 6 years old) the increase due to shade was just about the same as that due to 30 lbs. nitrogen as applied manure; now, as both tea and shade mature the shade is worth more in crop return, than 60 lbs. nitrogen.

The yields from this area are perhaps a little disappointing as a whole for tea in its 9th year, but it must be remembered that these yields are averages of several jats, some of which have proved most disappointing. While the yield from the best jat is 20.3 mds., the poorest is giving only 13.6 mds., both jats manured and under shade.

In another experiment, in this case light leaf tea planted in October 1939, there are 7 different varieties of shade trees. In 1945 its 6th year from planting, this area gave an average of over 17 mds. per acre unpruned. Variety of shade tree, whether

leguminous like Sau (black Siris) or non-leguminous, like Tung (A. Montana), has so far made no significant difference to crop, or to appearance of the tea. On this area also a trial of potash and phosphate manures shows no effect on yield from either mineral. In the intensive culture of tea, when yields in the neighbourhood of 20 mds. per acre are taken off annually, the question of potash or phosphate deficiency becomes of importance. Shade trees normally have a limited span of existence before they succumb to Canker and have to be removed. The wood, totalling many tons per acre, which has to be carted off the area, inevitably removes considerable quantities of the two minerals, and sooner or later replacement of these latter must be made in the form of manures.

Tea Seedlings versus Cuttings. Some doubt was felt regarding the growth into mature tea bushes, of vegetatively propagated "tea cuttings", compared with the normal seedling grown from a tea seed. In 1942 an area was put out in plots, half of which were planted with one year old seedlings of a certain jat, and the other half with one year old cuttings from the same jat of plants. In 1945 there was no appreciable difference in appearance and yield between the plots of seedlings and those of cuttings.

Plucking experiments. It has been an accepted fact for many years, and is supported by experimental results, that if any change is made in the method of plucking which results in more leaf being left on the bush, the immediate effect is loss in crop. If any change is made towards closer plucking a larger crop is the immediate result.

Thus, an unshaded area of good young tea plucked at 8″ and to the janam for some years, was divided into plots plucked at various levels from 4″ to the janam, up 8″ and a leaf. The year before the change in plucking was made, the area gave 13.3 mds. tea per acre. For the first few years the closer plucking viz. 4″ and 6″ to the janam gave substantial increases over 8″ to the janam, while the lighter plucking lost crop. In 1945 however, all yields are the same, and stand at about the same level as in the year before the experiment when all plots were plucked to 8″. The close plucked tea looks very poor compared with the lighter plucked and it is expected that the yield of the former will drop considerably behind the latter in future years. Even if it does not, the fact that, excepting for inital losses, the same crop will ultimately be given whether the plucking be to 6 or 8 inches of new wood is of the utmost importance in garden practice.

From every point of view a lightly plucked section is more easy and cheaper to maintain in condition than is a close plucked section. Cultivation is reduced to a minimum owing to better spread of the bushes, pruning is straight forward, and absence of diseases such as red rust and violet root rot, which are symptomatic of debility, are absent on the light plucked tea.

The burial of oilcake and green jungle. Two experiments started in 1941 deal with the desirability of hoeing in manure after application. It had previously been established that nothing is to be gained by hoeing in Sulphate of ammonia, but with

organic manures it was supposed that the burial of the manure was necessary to prevent loss of nitrogen in the form of ammonia given off from the rotting oilcake or jungle.

Two experiments were set out to examine the subject and the results show conclusively that the loss of nitrogen when the manures are not hoed in, is insufficient to alter the crop.

Bacteriological.

Mr. Benton, the Bacteriologist, continued to carry out experiments on manufacture of tea in the Darjeeling district throughout 1945. Striking results have been obtained as a result of modifications in the various processes, particularly in rolling and firing. These results will be communicated in a separate memorandum which is in process of preparation.

APPENDIX

Report on the position of the Tea Breeding Programme on Nov. 15 : 1945.

(1) It is estimated that conditions during the years 1940-1945 inclusive have resulted in the total loss of two years breeding work. This is irrecoverable loss on breeding work alone. Pure research has suffered more heavily, but it is gratifying to record this relatively light loss in practical results.

(2) With effect from Nov. 15th. 1945 it is possible for breeding work to proceed at pre war tempo (but see para. 69 below).

(3) Due to war conditions many breeding schemes have not been started as soon as was anticipated. The nature of these schemes is outlined in paras. (17) to (26) below.

(4) Those schemes which have been started have progressed in reasonably good accordance with the target dates as laid down in the breeding programme. In this connection great credit is due to the Assistant Botanist who has persisted with the original schedule in the face of many difficulties and for much of the time in the complete absence of competent botanical advice.

(5) The greatest disappointment has been the failure to foresee the need for increasing the number of seed bearing grafts (table III refers) and the failure to build up standard clones of all of the parents used in breeding (table II refers). This has resulted in an avoidable loss of two years work.

(6) Following the visit of the Botanist on War Leave from Iraq in April 1944 the breeding programme was speeded up so that more schemes are now in progress than was originally planned. Although many of these have been started late and are therefore behindhand, the increased number of schemes will eventually compensate for the lessened progress to date.

(7) According to the original programme the F1 offspring (see sub para. 20c) of one complete scheme were to be ready for trial each year commencing with 1946. By 1950 the offspring of five schemes were to have been tried. Now the first complete scheme will be ready for trial in 1947. Numbers of F1 offspring will become ready for trial each year thereafter. But owing to lack of seed bearing material no schemes, with the exception of Japvo, will be entirely complete until 1951, and the whole programme will not be back to target dates—*i.e.* lost time will not be made up—until 1952. The situation is given in detail in table II.

(8) Ten *line breeding* schemes are now in hand as against six originally planned to date. The object of each scheme is the production of a new variety.

(9) One of these schemes is only one year behind the target stage of progress for 1945. This is the JAPVO scheme (see table II). In this case it is possible to examine a new variety growing in the field, the plants of which are four years old. The results are encouraging and confirm that distinct improvements in uniformity over existing commercial *jats* are relatively easily obtainable at Tocklai. Manufacturing trials will begin in 1947. It is not proposed to distribute the variety in its present stage as further improvements in uniformity are likely to follow very rapidly.

(10) In addition to the line breeding schemes, *mass selection* schemes drawn up in 1940 are also in hand. These are four in number. They were started in 1943, a year later than was projected. Due to shortage of labour for maintaining the baries, which are isolated in heavy forest, growth of the plants has been retarded so that they are approximately one year behindhand, thus making a loss on these schemes of two years. In addition, one bari was completely destroyed by the military. This will be replanted in early 1946. Each of these baries is approximately one acre in extent. Seed from the three remaining baries will be available for planting in the trial plots in Nov.-Dec. 1946.

(11) Progress on the mass selection schemes is entirely due to the work of Mrs. Wight and the Assistant Botanist during the years 1940-1943. The isolation of these baries under ideal conditions in a forest reserve has been possible through the courtesy and co-operation of the Forest Dept.

GENERAL PROBLEMS.

(12) Any tea plant is infertile with its own pollen so that the tea of commerce is completely hybridised and excessively variable. This variability extends not only to external characteristics and adaptability to soil and climate, but also to the yield and manufacturing characteristics such as flavour and strength, which affect the marketable value of the tea. As all tea plants are of hybrid origin and as each tea plant must be fertilised with pollen from another plant, progeny grown from seed are necessarily mixed unless the plants which produce the seed have been selected by an expert. This selection necessitates many years of preliminary investigation.

(13) The seed bearing trees in a tea seed *bari* are normally grown from seed ; thus each seed bearer is genetically different from its neighbours, and as pollen is distributed at random by bees and wasps, the number of possible crosses in a seed *bari* of, say 20 acres, with 100 trees to the acre, is immense. In these circumstances uniform progeny are impossible. In the past no scientific tests were made of any of the plants which went to form the *bari*. By limiting the number of trees the number of crosses is reduced, and the scientific line

of attack on the problem is to establish CLONAL seed baries consisting of not less than two clones : this is because a clone enables one to obtain an indefinite number of identical plants.

(14) A clone is an indefinite extension of the plant body, and is obtained by VEGETATIVE PROPAGATION as opposed to propagation by seed. Small pieces of the stems of one chosen plant are taken and are induced to form roots, and eventually, to form a new plant. This process can be continued indefinitely. Each of these new plants is part of the original plant body and is identical with it in all respects. The variation which may be incidental on propagation by seed is thus circumvented. This indefinite extension of a plant body is known as a clone.

(15) It will be seen that a tea seed bari composed of one clone would not produce seed, as all the plants in the bari would be identical and tea is infertile with its own pollen. Two clones, suitably interplanted, would suffice, provided that they are interfertile. Unfortunately, various degrees of COMPATIBILITY exist between tea plants, such that pollen of "A" may or may not be suitable for "B". This factor has also to be investigated by the expert in charge of the selection. It is known however, that nine clones taken without regard to the compatibility factor will give a normal crop of seed. With a lesser number of clones a preliminary inspection of their compatibility is necessary to ensure a normal crop of seed. With only two clones it will be seen that there is likely to be minimal variation in the resultant crop of seed.

(16) The current line of attack on these problems at Tocklai is—

(*a*) Original selection of parent plants. This usually necessitates the manufacture of leaf from individual bushes by means of apparatus specially designed to deal with small quantities of leaf. The services of an experienced tea taster used to this kind of work are also necessary. The yield must be measured, as poor croppers are obviously undesirable. The aim of this selection is to pick out first class bushes as a basis for subsequent work. As the quality of the tea leaf varies at different times of the year, this has to be allowed for, and the minimal period for these tests is twelve months. In the initial stages of the work it had to be established that the variation in quality from year to year would not materially influence selection based on so short a period as twelve months.

(*b*) Breeding from the selected material. This is described below.

METHOD OF BREEDING.

(17) A simple way of understanding the problems involved in tea breeding is to regard the process as analagous to animal breeding in which two parents are

always necessary. On this conception two parental clones are required in a seed bari : one of these can be considered as the male and the other as the female, depending on which is giving and which is receiving the pollen.

(18) The production of these parents is the object of line breeding, which in our case starts with two parents possessing desirable characters but whose breeding capacity is unknown, and aims at selecting from their descendents two parents which will breed true to type. These two parents eventually make the two clones for the seed bari.

(19) Continued breeding from the offspring of any one cross—that is continued breeding from an initial pair of parents—results in a family tree which is intended to culminate in a new variety. This is what is meant by *line breeding* the aim of which is to produce a variety which originates from a single pair of parents only.

(20) In the family tree arising from the initial pair of parents, three branches in the line of descent become possible after the offspring have been obtained from the first mating

(*a*) By back crosses of the progeny to one of the initial parent plants. If this plant is considered to be the male, the back cross would be a *father* × *daughter* mating. The resultant line of descent obtained by repeated back crosses to the original male parent would be analagous to the male line of descent in a similar system of animal breeding.

(*b*) By back crosses of the same progeny to the other parent. Continuing the analogy, this would be regarded as a *mother* × *son* mating. The resultant line of descent obtained by repeated back crosses to the original female parent would be analagous to the female line of descent in a similar system of animal breeding.

(*c*) Using the same analogy, successive *brother* × *sister* matings are possible, giving a line of descent in which the F1 (first filial), F2 (second filial), F3 (third filial) and successive generations are directly descended one from the other.

(21) According to the exigences of the scheme, crosses between the above separately considered lines of descent may be made. Amongst other factors, the need for making such crosses would be determined by the need for counteracting any loss of vigour which might be induced by continued inbreeding down one line of descent.

(22) There are several reasons against commencing a tea breeding scheme with only one pair of parents. More than one pair of parents desirable for achieving the set object can be chosen. Each pair of parents will be likely to give rise to two

individuals which could be selected as the progenitors of the new variety. There will be a line of descent from each pair of parents, and the best line can eventually be retained and those which are more unsatisfactory discarded.

(23) In the technique of breeding, each line of descent can give a three branched family tree as described in para. (20).

(24) Most of the line breeding schemes at Tocklai have been started with three desirable plants A, B, C. These three individuals give three possible pairs of parents AB, AC, BC, the lines of descent from each of which is investigated. This is shown in table I.

(25) With an initial choice of two desirable plants only one line of descent is possible *viz.* A x B. With an initial choice of three desirable plants three lines of descent are possible *viz.* A x B, A x C, B x C. Four plants give six possible pairs of parents with six lines of descent to be investigated. In general n plants give $\frac{n^2-n}{2}$ possible pairs of parents. It will be seen that the numbers of possible matings rise very rapidly with a slight increase in the number of plants selected with which to begin a scheme.

(26) It is not essential to make every possible mating amongst a number of desirable plants selected as suitable for inclusion in one scheme. With many desirable plants selected to begin a scheme, time and labour prevent all possible matings being made. Some choice has to be exercised amongst the possibilities. This is illustrated by the details given for the Deopathar scheme in Table I. Generally, the current schemes start with three plants, all possible matings being made in the first stage of the scheme.

LINE BREEDING at TOCKLAI.

(27) The main breeding programme at Tocklai is based upon this method of advance. It is directed towards the production of bi-parental baries *i.e.*, bi-clonal baries. Work along these lines allows for the improvement of the variety ad-infinitum. But an appreciable time must elapse before large scale production of seed is possible.

(28) Breeding down the lines of descent in any one of these schemes will cease either

(*a*) When the variety is considered satisfactory from the point of view of uniformity, vigour and manufacturing characters.

(*b*) Or when it is considered that the production of satisfactory results is not worth the time and expense involed in pursuing the particular scheme.

(29) In the latter case the scheme would be abandoned in favour of another potential variety derived from other parents. The elimination of unsatisfactory schemes is covered by provision for the initiation of a regular succession of new schemes (see para. 39).

(30) It is possible that in some cases the offspring of the initial pair of parents will be satisfactory. In this case no further breeding would be necessary and clones from the initial parents would be the producers of the new variety.

(31) It will thus be seen from para (38) that with extraordinary good luck it might be possible to distribute a new variety at the end of the seventh year after commencing a scheme. Our current time table is based on fifteen years work on each scheme.

(32) Ten line breeding schemes are now in hand, each of which aims at producing a new variety. Each scheme is known by a name such as JAPVO which can be used as the interim name of the new variety. The names provide a designation by which unqualified field staff can easily remember the location of particular plots of plants in the field. The use of numbers alone has been found unsatisfactory. The series of names in use is taken from the mountain ranges on the NW, N and NE frontiers of India. The names are impersonal, indigenous and avoid confusion with existing *jat* names.

MASS SELECTION AT TOCKLAI.

(33) An alternative to line breeding is mass selection, whereby many similar parents are chosen and allowed to breed indiscriminately amongst themselves. Some degree of mass selection is practised in the better commercial seed baries, but the number of parents in the bari is far too large. The main failings of commercial concerns are

(*a*) That few Managers understand criteria of selection.

(*b*) There is no limit imposed on the number of parent plants in the bari.

If the number of parents are cut down and the deficit in individual plants made up by vegetative propagation, considerable improvements should be possible.

(34) The Tocklai mass selection schemes presuppose the production of varieties which are an improvement over existing commercial *jats*, but do not anticipate such a high degree of improvement as is possible with line breeding. Improvements ad-infinitum are not possibly by the sole pursuit of mass selection. The results from the Tocklai schemes are therefore expected to be of less permanent value than those from line breeding. They can however be obtained more quickly. Parent clones which are proved satisfactory can be made available

for distribution in the first place 4.5 times more quickly than those from line breeding.

(35) Work on four baries, each consisting of nine clones, was commenced in 1943 (see para. 10). One was destroyed by the Military. Seed from the remaining three baries is expected for trial in 1946.

(36) Modifications of mass selection whereby Managers themselves will be able to improve existing small seed baries for the production of their own seed were contemplated before the war and will be put into operation as soon as possible. One commercial concern has been using these methods since 1938, though it is understood that the criteria of selection is leaf form alone.

CLONAL GARDENS.

(37) Ordinary tea garden extensions consisting of mono-clonal material have been visualised by the Agric. Branch. Work along these lines has been proceeding during the absence of the Botanist. This possibility is borne in mind, though the danger of the total loss of a garden so planted, through the incidence of disease, cannot be too strongly emphasised. Many years' experience with the clone would be necessary before such extensions could be generally recommended. A drawback of the method is the big time lag inevitable in building up an initial clone sufficiently large to provide the necessary material.

TIME SCALE.

(38) The minimal time scale for line breeding is as follows :—

Seed bearing grafts established	...	Year Y
FI seed produced	...	„ Y+2
Trial manufacture	...	„ Y+6
First back cross	...	„ Y+6

Shortage of material and staff may easily extend this by two to three years. In the beginning, methods and sources of material have to be investigated. Then the parents for grafting have to be selected. All this involves an initial non recurring time lag which cannot well be less than two years. Tea breeding at Tocklai began in 1936. Due to various practical difficulties encountered in the early stages of the work, cut and dried schemes did not commence until 1939. In view of the delays subsequent to the Botanist proceeding on military service it has been decided to date progress with reference to the year 1940.

(39) Our aim is to commence one new scheme per year—

(*a*) Approx. half of these potential new varieties should be worth trial under the supervision of the District Officers.

(*b*) Half of the new varieties tried should be worth distributing.

(*c*) This means one new variety every four years.

(*d*) On the basis of replanting every 20 years, a Manager should thus have five new varieties to choose from, one of which is likely to be suited to his particular conditions.

(40) The invention of a suitable machine by Mr. Pizey of Messrs. McLeod & Co. has overcome the need for hand manufacture. Mechanical means of rolling small samples are available such that

(*a*) A greatly increased number of repeats can be done at once, thus enabling a bigger range of material to be examined for possible parents.

(*b*) Smaller trial plots of F1 progeny can be used in an earlier stage of growth.

The above time scale (para. 38) takes these factors into account.

PROPAGATION.

(41) Propagation work was transferred trom the Mycological to the Botanical Branch in 1938. Material results to date are indicated in the foregoing paras. Our conclusions regarding principle are given in paras. (43) to (57) below.

(42) Current and incomplete work aims at finding the best methods of packing and the best stage of growth for distributing large quantities of clonal material to any given location in India. To usefully apply the results of the breeding programme the distribution of vegetative material must be made comparable in simplicity and success with the distribution of seed.

CUTTINGS.

(43) More than 70% of all tea gives over 60% rooting. Thus the question of whether or not a plant will root well is not of very material importance in selection. Work may proceed on the assumption that most of the material selected will give a sufficiently good degree of rooting, and obstinate cases encountered may be dealt with separately.

(44) The above statement includes a normal percentage of plants showing the *zig-zag* character. This character is known to be associated with poor rooting and also

with pathological symptoms such as "rim blight" and die—back. The elimination of the *zig-zag* character is therefore necessary at an early stage of selection. The *zig-zag* character seems to be the chief trouble in the poor rooting of some of the lighter leaf types.

(45) The relation between potash content and rooting capacity has been examined. A low degree of correlation was found which is not likely to be of any practical value in selection. The investigation however, produced a considerable amount of data which will be of value in furthering our knowledge of type varieties of the tea plant.

(46) Individual plants show significant differences in the ability to form roots upon cuttings.

(47) The ability of tea plants to form roots upon cuttings is significantly related to the parental origin of the plants. Rooting capacity is therefore a heritable character.

(48) The "colour" (greenness) of the leaf is significantly related to rooting capacity.

(49) The presence of the *zig-zag* character is significantly associated with poor rooting.

(50) Indole B acetic acid was found to have a slightly beneficial effect at a low degree of significance, on the percentage of cuttings to form roots. Roots on the treated cuttings were larger and better but no quantitative estimate was made of this factor.

(51) Time of the year at which the cuttings are taken has a significant effect on success. The effect of time of the year is independent of the age of the cutting used. April and June were found to be the best months. May cuttings were not investigated, but by inference, April, May and June are the best months. These results require aligning with conflicting reports from garden managers.

BUD GRAFTS.

(52) Detailed knowledge based on experiments is lacking, but the field technique has reached a satisfactory stage of proficiency.

(53) Stock—scion compatibility exists in tea.

(54) The factors influencing a successful union seem to reside more particularly in the stock : "compatibility" does not seem to be an equally reciprocal relation.

(55) The parentage of stocks raised from seed is important. Even though such stocks vary individually, a certain percentage serve to confer either a common "goodness" or a common "badness".

(56) The nature of the distribution of stock-scion compatibility is not likely to materially influence any desired programme of propagation. Clonal rootstock is not likely to be necessary for the generality of unions. Provided that a suitable source of seed for rootstock material is chosen, then grafting may proceed on the assumption that the majority of the bud types will give a sufficiently high percentage of unions. Individual cases of difficulty would be dealt with as they occur. The probability of difficulty arising with rootstocks raised from seed is not sufficiently great to merit a-priori consideration, provided that the stocks are raised from suitable parents.

(57) Other considerations, such as dwarfing effect, possible effect on quality, etc., are not of material importance in our present line of work. It is to be noted that this aspect leads into a sea of difficulties, which, in the case of apple, have been solved by devoting the activities, of an entire research station to these problems alone for a period of something like twenty years.

CLASSIFICATION

(58) The classification of properly recognised varieties of tea is of prime importance. Outside Russia no satisfactory system has been evolved. We have inadequate knowledge of the details of the Russian work, but so far as can be seen our conclusions are in agreement with the main conclusions of the Russian work so far available.

(59) Liaison with the Russian research workers would be of mutual advantage, particularly if exchange visits could be arranged.

(60) By 1939 the Botanist was able to recognise and classify certain main or key types of tea plant. The Quarterly Report for June 1939 refers.

(61) The classification and relationship of the types recognised by the Botanist was described in the abovementioned report, but no description of the types was given. It was planned to make these descriptions in 1940. Due to the Botanist proceeding on military service in late 1940, the whole of his available time in early 1940 was spent in organising the propagation and breeding work with a view to its continuance during his absence. Subsequent events have justified this policy.

(62) The position with regard to classification now is that the only descriptions of the types isolated are the actual plants themselves growing in the Tocklai plots.

(63) One of the first duties of the Botanist on his return to the Station should be the Botanical description of the type plants isolated by him in the Tocklai plots.

The exact nature of the diagnostic characters used are at present known only to the Botanist.

(64) The importance of establishing clones from plants representative of botanical types cannot be too strongly emphasised. There is no permanency attached to the varieties of the seed merchant, nor to those visualised in the Tocklai breeding schemes, which allow for continual change in connection with continual improvement. The value of basing recondite research on such ephemeral "standards" might well be questioned. Furthermore, each variety is evolved to supply a specific need, quite independently of our conceptipn of a graded and standard series of all the types of plant possible; and the only enduring meaning which can be attached to any particular variety is by referring it to a series of recognised botanical types. Adequate supplies of clonal material of recognised types might well make the best basis for most routine field and factory experiments. Recent work by the Chemical Branch on the nitrogen content of standard types selected by the Botanist supports this contention.

(65) It is planned to resume the study of these types in 1947 after the return of the Botanist from Home Leave. Clonal material could be made available in the following year.

(66) Dr. Wight has recently discussed the classifiction of tea with Capt. Kingdon Ward, the noted Botanist and explorer, who has a life time experience of the N. E. Frontier. Capt. Kingdon Ward is definitely interested in the further investigation of the geographical home of tea in collaboration with Dr. Wight. It is pointed out that as far as can be ascertained, the tea of commerce has been derived from relatively few sources and the potentialities of material existing wild in nature has not been properly investigated.

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